STATIC AND DYNAMIC ANALYSIS ON ENVIRONMENTAL CONTROL SYSTEM OF REHEATER ATTACHMENT FOR A TYPICAL NAVAL FIGHTER AIRCRAFT

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ABSTRACT
In preparing this paper an attempt has been made to present concisely the most important and useful results of static and dynamic analysis on environmental control system of reheater attachment for a typical naval fighter aircraft. In order to achieve this, the proper design, modeling, analysis and manufacturing of a component follows a well-defined organized system. This can be achieved by modernizing the system of working with the usage of special tools, techniques and up-to-date software. The typical naval fighter aircraft are subjected to arrest landing by landing hooks for short distance runway landing. During the time of arrest landing the shock load produced each and every structural component on the aircraft. The re-heater attachments are very important structural components of an aircraft as they resist very high loads resulting from arrest landing of a typical naval fighter aircraft.

KEYWORDS: *ECS, Re-heater attachment, naval fighter aircraft, shock load.*

I. INTRODUCTION

1.1 Naval fighter aircraft

A naval fighter aircraft is a military aircraft designed primarily for air-to-air combat with other aircraft, as opposed to a bomber, which is designed primarily to attack ground targets by dropping bombs. The hallmarks of a fighter are its small size, speed and maneuverability. Many fighters have secondary ground-attack capabilities, and some are dual-rolled as fighter-bombers. Consequently, the term "fighter" is sometimes extended colloquially to include dedicated ground-attack aircraft.

1.2 Aircraft environmental control system

Aircraft pressure vessel which includes the cockpit (flight deck) cabin and interior compartments. Safety monitoring is also performed e.g. cabin altitude (ZC), cabin ΔP. On transport - category aircraft, ECS comprises various systems performing the following functions: bleed air supply, bleed leak detection, air conditioning, distribution, avionics cooling, cabin pressurization control, oxygen supply. The trend today is towards increasing integration of all air systems, including wing anti - ice/de- ice functions via common controller architecture. The current work done on the re-heater attachment on the typical naval aircraft. The attachment brackets installing on station 19A and 19B.

II. METHODOLOGY

2.1 Static and Dynamic analysis of aircraft stiffened panel

Stiffened panel is a component in aircraft that is used to fasten the stiffener and the skin. These are components that carry and allocate the loads throughout the surface of the fuselage or the wing. These panels are present in both fuselage and wings. When we consider the issue i.e. Resistance of the Aircraft's skin towards the load applied on it, due to frailty the Aircraft skin is easily deformed.

2.2 Static and Dynamic analysis of typical wing structure of Aircraft using NASTRAN

The main objective is to fix a approximate structure within the given envelope. Sizing is done by using classical Engineering theories and FEA packages (MSC Nastran and MSC patran) Skin and web.

2.3 Dynamic Analysis of Compression mounting bracket:

The compressor mounting bracket may fail due to response in dynamic analysis, but in the static analysis gives a realistic method for it design validation. With the use of the above methodology, a new compressor mounting bracket is analyzed and optimized, also, the importance of certain ribs or stiffness is studies using the proposed methodology.

III. SOFTWARE USED

3.1 Patran

Patran is the world's most widely used pre/post-processing software for Finite Element Analysis (FEA), providing solid modeling, meshing, and analysis setup for MSC Nastran, Marc, Abacus, LS-DYNA, ANSYS, and Pam-Crash.

Meshes are easily created on surfaces and solids alike using fully automated meshing routines (including hex meshing), manual methods that provide more control, or combinations of both.

3.2 MSC Nastran

Hence, MSC is a pioneer in simulation solutions to improve time-to-market. The company's solutions allow manufactures to accurately predict how their designs will behave in their intended environments, without having to build and test multiple physical prototypes.

IV. STATIC ANALYSIS

4.2 Definition of Static Analysis

A static analysis calculates the effects of *steady* loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads.

4.3 Loads in a Static Analysis

Static analysis is used to determine the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. *Steady* loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The kinds of loading that can be applied in a static analysis include: Externally applied forces and pressures, Steady-state inertial forces (such as gravity or rotational velocity), Imposed (non-zero) displacements, Temperatures (for thermal strain), Fluencies (for nuclear swelling)

4.4 Linear static analysis for re-heater attachment

Positive & negative static load case for Bracket 1&2:
Bracket 1 - Nx=6, Ny=3.44 ,Nz=8.45
Bracket 2 - Nx=-4, Ny=-3.44 , Nz=-5.84
Calculation for static loads
Positive load factors
Fx=6*9.81*1.5*6.35 = **560.641 N**
Fy=3.44*9.81*1.5*6.35 **= 321.434 N**
Fz=8.45*9.81*1.5*6.35 **= 789.570 N**

Negative load factors
Fx=-4*9.81*1.5*6.35 **= - 373.761 N**
Fy=-3.44*9.81*1.5*6.35 **= - 321.434 N**
Fz=-5.84*9.81*1.5*6.35 **= - 545.691 N**
R.F calculation:

R.F = Ultimate stress/applied stress (ultimate stress=440 Mpa) (1)

4.5 Experimental tabulation

By comparing actual and optimize design (1&2) for bracket 1 and bracket 2 in which keeping mass constant in 1D by varying mass and thickness in 2D is given in the table below

Table 1 Properties for bracket-1 (actual and optimize design 1 and 2)

Element/ property	**Material**	**Mass in kg**	**Thickness in mm**
0D	Aluminum	6.35	-
1D	Aluminum	-	1
2D	Aluminum	1.3	3
optimize design-1			
2D	Aluminum	0.8	3
optimize design-2			
2D	Aluminum	0.694	2.5

Table 2 Properties for bracket-2 (actual and optimize design 1 and 2)

Element/ property	**Material**	**Mass in kg**	**Thickness in mm**
0D	Aluminum	6.35	-
1D	Aluminum	-	1
2D	Aluminum	0.68	3
optimize design-1			
2D	Aluminum	0.58	3
optimize design-2			
2D	Aluminum	0.56	2.5

Table 3 Static analysis tabulated result

Compo nent	**Model**	**M Kg**	**L-1 Mpa**	**L -2 Mpa**	**R.F (no unit)**
Bracket-1	Actual	**1.3**	100	92.1	4.4
	Optimize-1	**0.83**	132	97.2	3.3
	Optimize-2	**0.69**	139	100	3.1
Bracket-2	Actual	**0.68**	96.5	72.6	4.5
	Optimize-1	**0.58**	98.5	74.6	4.4
	Optimize-2	**0.56**	102	81.4	4.3

4.6 Discussion

Bracket-1 and Bracket-2:
Static analysis for bracket-1 has been done and the values are tabulated. From this value we came to know that R.F values are much high. So we have done the weight optimization process. By the optimization process we reduced the weight and required R.F value is attained.

V. MODAL ANALYSES

5.1Model analysis dynamic characteristic

The structures exposed to dynamic forces the knowledge of dynamic characteristics of these structures is of great importance. The most important intrinsic dynamic characteristics of linear dynamic systems are the natural frequency, the associated mode shape, Damping.

The natural frequencies and associated mode shapes may be analyzed for both damped and un-damped linear dynamic systems .When a structure, machine or any system is excited, its response exhibits a sharp peak at resonance when the forcing frequency is equal to its natural frequency when damping is not large. Since any dynamic response of a structure can be obtained as a combination of its modes, knowledge of the mode shapes, modal frequencies and modal damping ratios constitute a complete dynamic describes about the structure.

The deflection shape measured is valid only for the force /frequency associated with the operating conditions; as such, we cannot get information about deflections under other forces and frequencies .However , the measured deflection shape can be quite useful. For example, if a particular part or location is found to have excessive deflection, we can stiffen that part or location .This in effect, increases the natural frequency beyond the operational frequency range of the system.

5.2 Model analysis of re-heater attachment

The model analysis of the re-heater attachment on station 19a and 19b is done by the following procedure. Attachment brackets surfaces are extracted and meshing and given the property to the finite elements.0D point element created on the cg point of the re-heater and applied the lumped mass property to the 0D element.

LRU attachment points are attached to the 0 D lumped elements by creating 1D beam element between the points and 0D element. The boundary coordinates are specified and the nodes are translational constrain at x,y,z direction on the specified node. The same procedure followed for all the constrain point.

Modal analysis followed by the given bracket by using MSC patran and analysis done by using MSC nastran and the frequency carefully noted on both the given and optimized brackets.

5.3 Experiment and tabulation

In this model analysis we calculating the values of Mode 1 & Mode 2 frequency levels by varying the mass of actual and optimize design 1 and 2 to analyze the dynamic characteristics.

Table 4 Model analysis tabulated result

Component	**Model**	**Mass in kg**	**Mode 1&2 Frequency in Hz**
Bracket-1	Actual design	1.3	37.87, 53.85
	Optimize design-1	0.83	29.79, 38.72
	Optimize design-2	0.69	25.79, 34.05
Bracket-2	Actual design	0.68	4.8, 5.2
	Optimize design-1	0.58	4.5, 4.8
	Optimize design-2	0.56	4.3, 4.7

5.4 Discussion

Bracket-1:

Modal analysis for bracket-1 actual design having the above tabulated values. The optimized design 1&2 having the lower frequency to compare with actual design analysis shown in table.

VI. TRANSIENT RESPONSE ANALYSES

6.1 Forced dynamic response

Transient response analysis is the most general method for computing forced dynamic response. The purpose of a transient response analysis is to compute the behavior of a structure subjected to time-varying excitation. The transient excitation is explicitly defined in the time domain. All of the forces applied to the structure are known at each instant in time. Forces can be in the form of applied forces and/or enforced motions

6.2 Integration Time Step

For a given integration time step, integration errors increase with increasing natural frequency because there is an upper limit to the frequency that can be represented by a given time step. Also, integration errors accumulate with total time. In both direct and modal transient analysis, the cost of integration is directly proportional to the number of time steps. For example, doubling the load duration doubles the integration effort. In specifying the duration of the analysis on the TSTEP entry, it is important to use an adequate length of time to properly capture long period (low frequency) response.

6.3 Calculation formula for transient response analysis

Calculating time step

Time period (t) =1/f (2)

f = mode frequency

Number of time steps =T/t (3)

T= transient time period

Non spatial PCL-expression:

294.*sin d (600.*'t) (4)

In transient response analysis we analyze the force dynamic responses for bracket -1 and bracket - 2 by varying the mass in which there is an changes happen in actual and optimization design1&2, stress values along x,yand z directions. The model calculation is given for actual design and bracket -1(optimization) is given below

Bracket-1(actual design)

Time period (t)

= 1/f (f=513.56) = 1/(10*513.56) **=1.94 e-4 sec**

Number of time steps = T/t (T=0.030 sec)

= 0.030/1.94 e-4 **=154.6 sec**

Shock von mises stress on x direction =55.6 Mpa

Shock von mises stress on y direction =63.7 Mpa

Shock von mises stress on z direction =91.6 Mpa

Bracket-1(optimize-1)

Time period(t) =1/f (f=420)

=1/(10*420) **= 2.38 e-4 sec**

Number of time steps =T/t (T=0.030 sec)

=0.030/1.94 e-4 **= 126.05 sec**

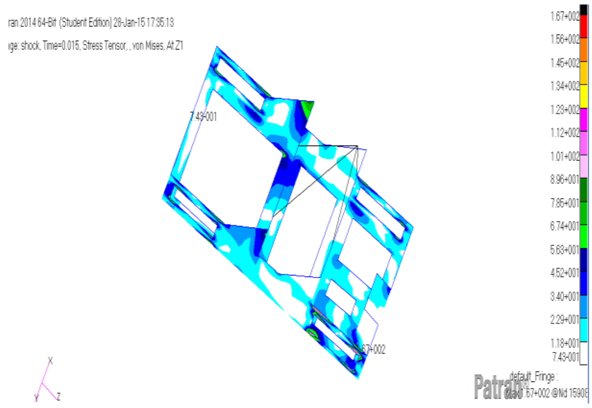

Figure 1 - Shock von mises stress on x direction =110 Mpa

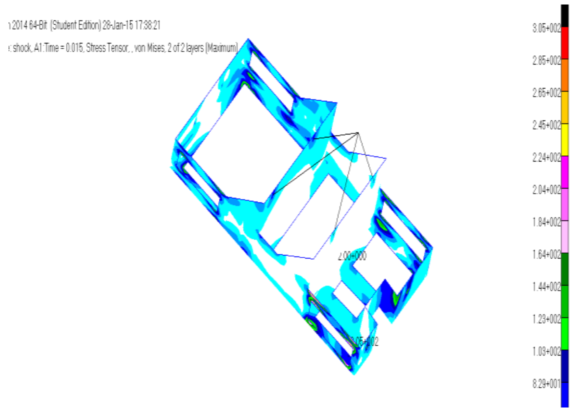

Figure 2 - Shock von mises stress on y direction =184 Mpa

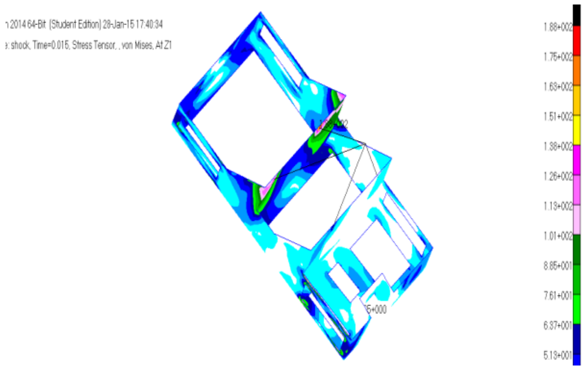

Figure 3 - Shock von mises stress on z direction =113 Mpa

Table 5 Transient response analysis

Component	Model design	Mass in Kg	σ (x) Mpa	σ (y) Mpa	σ (z) Mpa
Bracket-1	Actual	1.3	55.6	63.7	91.6
	Optimize-1	0.83	110	184	113
	Optimize-2	0.69	146	262	163
Bracket-2	Actual	0.68	292	119	104
	Optimize-1	0.58	612	174	159
	Optimize-2	0.56	738	193	242

6.4 Discussion

Bracket-1 and Bracket-2

Transient response analysis for bracket-1 has been done and the values are tabulated. From this value we came to know that R.F values are much high. So we have done the weight optimization process. By the optimization process we optimized the weight and the von- mises stress.

VII. CONCLUSION

Static and dynamic analysis of a environmental control system of re-heater attachment for a typical NAVAL fighter aircraft. is carried out using finite element stress analysis package MSC PATRAN/NASTRAN to find out maximum stress and minimum stress.

In the above work we get the ECS component of a re-heater attachment done the static and dynamic analysis and get the mode frequency and the maximum and minimum von mises stress. According to the values to plan to increasing the R.F values because many of the surfaces on the component having low stress. The stress plan to be increased four times to its actual value. Optimizing of the given brackets done by design the holes and reduce the thickness of the component. After optimize the

design the static and dynamic analysis carried out on it. Finally we increase the von mises stress of the brackets compare to its actual design.
The plan of future work is to optimize the design parameters which include thickness and materials of brackets to find the three dimensional stresses occurring in the body by various loading conditions.

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